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# Arrangement for supplying voltage to a number of loads, and a controller for a vehicle power supply system having at least two energy stores

The invention relates to an arrangement for supplying voltage to a number of loads, in particular for a vehicle. The invention furthermore relates to a controller for a vehicle power supply system having at least two energy stores.

The development of new components in automobile construction, such as electromagnetic valve control (referred to as EMVS for short), or else loads such as the electric front windshield heating, as well as the trend to provide electrical drives for components which were previously driven by means of belts, have resulted in the total electrical power of the loads to be supplied rising dramatically. An increased power demand resulting from this cannot in this case be covered by a conventional 12 V vehicle power supply system with a 14 V generator voltage. It is thus known for a vehicle power supply system to be provided having a number of voltage levels, for example 12 V and 42 V, or having a number of batteries. The development is being driven in specific directions by the continuously increasing demands for the availability of the supply for the vehicle power supply system, as well.

By way of example, DE 40 28 242 A1 discloses an arrangement for a vehicle power supply system having two batteries, which are connected to one another during normal operation and are disconnected when required. When the two batteries are connected, they are charged at the same time by a generator. In this case, it is impossible to connect the loads in a manner

which takes account of the capacity of the batteries.

DE 100 33 317 A1 discloses an arrangement having a self-latching relay, which results in switching to an emergency battery in order to provide an emergency supply to the loads. In this case, it is not possible to take account of the amount of charge that is required to be drawn by the respective load. The various loads can thus draw charge from one another. Furthermore, the entire arrangement malfunctions if the relay fails.

Furthermore, DE 196 45 944 A1 discloses a controller for a vehicle power supply system having at least two batteries which can be charged by a generator. In this case, the controller controls a connection between the two batteries such that the connection is opened or closed as a function of data which can be predetermined, for example recharging of a specific battery. In this case, each battery can be discharged on its own by loads connected to it. This means that the relevant battery cannot provide sufficient capacity for all of the loads at any time.

In order in particular to allow individual loads to be supplied in critical situations, these loads have respectively associated separate buffer or emergency batteries, independently of the capacity of the relevant battery. Such dedicated-load buffer batteries are so-called primary batteries (non-rechargeable), which have a limited life. Alternatively, the buffer batteries are in the form of rechargeable batteries. Dedicated-load emergency supplies are particularly complex and costly. Furthermore, as a result of the increasing number of electronic loads which require such a backup supply, the space required has increased. Furthermore, such additional emergency supplies are particularly heavy in weight, which leads to increased

vehicle fuel consumption.

Finally, DE 199 21 451 C1 discloses a vehicle power supply system for supplying electrically powered loads in motor vehicles. In this case, a number of electrical power supply sources, which also are at different voltages, as well as sensor means for detection of failure of an electrical power supply source are provided, which operate switching means for connection of an intact electrical power supply source. The vehicle power supply system has, as the multiple voltage vehicle power supply system, a number of vehicle power supply system circuits which are operated at different voltages and each have appropriately configured loads. Each vehicle power supply system circuit is continuously connected to its associated electrical power supply source. Furthermore, crossover voltage means are provided, which automatically ensure, in the event of failure or malfunctioning of one vehicle power supply system circuit, that the loads which are connected to this failed vehicle power supply system circuit are supplied from one of the other vehicle power supply system circuits, such that an additional power supply connection is connected to the failed vehicle power supply system circuit from an intact vehicle power supply system circuit.

The invention is thus based on the object of specifying an arrangement for supplying voltage to a number of loads, in particular in a vehicle, which allows individual loads to be provided with an emergency supply in a particularly simple manner. A further object is to specify a controller for a vehicle power supply system which has at least two energy stores, which controller allows individual loads to be provided with an emergency supply in a particularly simple manner.

According to the invention, the object is achieved by the characterizing features of the independent claims. Advantageous embodiments are the subject matter of the dependent claims.

The invention is based on the idea that loads can be supplied in a simple manner by dispensing with separate emergency supplies in the form of dedicated-load emergency batteries or rechargeable batteries. The number of electrical loads to be supplied comprises, however, those loads which have to be supplied, by virtue of their function or for safety reasons, even in critical situations, and those loads which have to be supplied only during normal operation. For this purpose, the arrangement has a vehicle power supply system which has at least two energy stores, a first energy store of which is connected in a starter circuit element to a starter for starting an engine, and a second energy store of which is connected in a load circuit element to the loads. In this case, the starter circuit element is connected to the load circuit element via a coupling element, in which case a number of loads which are classified as being safety-relevant can be connected to the starter circuit element via an additional coupling element.

The safety-relevant loads are expediently coupled to the starter circuit element entirely or largely without any quiescent current by means of the additional coupling element. This ensures that the starter circuit element and, in particular, the energy store which is connected to it, for example a so-called starter battery, are largely free of quiescent currents. Particularly when the vehicle is stationary, the generator is switched off or the engine is stationary, the energy store for the starter circuit element is thus discharged only slowly, or not at all, as a result of quiescent currents of connected loads. This allows

the energy store to hold an amount of energy which is sufficient to allow the vehicle to be started.

A single additional coupling element is preferably associated with each safety-relevant load. This allows individual electrical loads to be switched off, in addition to the slight discharging, or no discharging whatsoever, of the energy store as a result of quiescent currents for safety-relevant loads, if the energy store has insufficient capacity to provide a starting capability. By way of example, the safety-relevant loads are for this purpose prioritized on the basis of their function, so that individual loads are switched off in a predetermined sequence, as required. In other words: the safety-relevant loads are sorted on the basis of their ranking, and are switched in accordance with their ranking. This allows process-dependent and, furthermore, prioritized switching, disconnection or connection, of loads which, in particular, ensure the functionality of the vehicle and/or the protection of the environment. Furthermore, this reliably avoids a dip in the voltage of the energy store or the electrical power supply source. This therefore allows particularly advantageous use of the energy store for the starter circuit element.

The coupling element and the additional coupling element are advantageously integrated in a controller. This allows the coupling elements to be arranged in a particularly simple and compact form in the controller. Furthermore, the wiring complexity is low, and this allows simple and rapid maintenance of the coupling elements for both circuit elements, and all of the loads.

The controller preferably has at least one means for detection of operating variables which represent the respective circuit elements. A voltmeter and/or an

ammeter is provided, for example, as the means for detection of operating variables, in particular for monitoring of both circuit elements and to maintain sufficient capacity in the relevant energy store to ensure functionality or the capability to start the vehicle. In addition, a clock may be provided as the means for measurement of the amount of charge drawn from the respective energy store.

Alternatively or additionally, the controller has at least one means for detection of operating variables which represent the respective safety-relevant loads. A voltmeter, an ammeter and/or a clock are/is provided for each power output of the respective load, depending on its type and configuration. The respective amount of charge drawn and, if appropriate, the demand are determined on a load-specific basis from the detected operating variables.

The controller is expediently designed to control the respective coupling element for the circuit elements and/or the safety-relevant loads. For example, if the battery capacity in the starter circuit element is insufficient for the requirements, this allows individual loads to be switched directly, in particular to be disconnected and/or connected. Furthermore, this allows mutual recharging of the energy store, by means of a controllable DC/DC converter. The controller is preferably in this case designed such that the loads and/or the safety-relevant loads are switched as a function of the detected operating variables.

In one preferred embodiment, the additional coupling element comprises at least one field-effect transistor and a diode. The coupling element which connects the circuit elements is preferably in the form of a switch or field-effect transistor. The use of semiconductor elements for the coupling element is particularly

simple and cost-effective.

With regard to the controller for a vehicle power supply system which has at least two energy stores, with a starter circuit element which comprises a first energy store and a starter for starting an engine, and a load circuit element which comprises a second energy store and a number of loads, one coupling element is, according to the invention, provided for coupling the starter circuit element to the load circuit element, and at least one additional coupling element is provided for coupling a number of loads, which are classified as being safety-relevant, to the starter circuit element. A controller designed in this way allows largely variable configuration of the vehicle power supply system structure while providing an adequate emergency supply to safety-relevant loads at the same time.

At least one means for detection of operating variables which represent the circuit elements and/or the loads is expediently provided. In this case, the controller preferably has at least one data processing unit for processing operating variables which represent the circuit elements and/or the loads. The controller can be linked to other bus-compatible controllers in the vehicle by the use of a bus-compatible data processing unit, for example a microprocessor. Furthermore, various types of operating data can be interchanged and can be taken into account by means of the associated controller in order to control the vehicle power supply system. In particular, the integration and/or linking of the coupling elements in or at the controller allows other operating variables, such as a rotation speed, or variables which are typical of the vehicle power supply system, such as generator data, to be taken into account in the switching of the coupling elements.

The energy stores in the circuit elements are preferably of such a size that they have the amount of charge required for cold starting of the internal combustion engine or of the engine only when they are interconnected. This allows the weight and size of the individual energy stores or batteries to be optimized.

The advantages achieved by the invention are, in particular, that the subdivision of the feed for safety-relevant loads into an operating supply and an emergency supply on the basis of mutually decoupled circuit elements of a vehicle power supply system means that there is no need for dedicated-load, and thus additional, emergency batteries, buffer rechargeable batteries and their charging devices. Furthermore, such a redundant feed for safety-relevant loads allows them to be functional in virtually all situations. Furthermore, such separation of the feed into an emergency supply and a standard supply by means of mutually decoupled circuit elements which are arranged physically separately ensures that, even in the event of failure of one of the energy stores as a result of damage caused by an accident or by an excessive amount of charge being drawn, a sufficient supply for the safety-relevant loads is always possible. By way of example, one of the energy stores together with an associated preferred charging device is in this case designed only to provide the emergency supply. An amount of charge made available from the relevant energy store in this way can thus be distributed between associated power paths for various safety-relevant loads. It has therefore allowed greater availability in the case of an emergency than with individual emergency supplies in the form of buffer batteries.

These and other objects, advantages and features of the present invention will be explained in more detail in

the following detailed description of preferred exemplary embodiments of the invention with reference to the drawing, in which:

Figure 1 shows, schematically, an arrangement for supplying voltage to a number of loads, having a controller and having a vehicle power supply system which has a starter circuit element and a load circuit element,

Figure 2 shows, schematically, the controller as illustrated in Figure 1 in detail, and

Figure 3 shows, schematically, the arrangement for supplying voltage, as shown in Figure 1, for a vehicle power supply system.

Parts which correspond to one another are provided with the same reference symbols in all of the figures.

Figure 1 shows, schematically, an arrangement 1 for supplying voltage to a number of loads 2. The arrangement 1 has two energy stores 4a and 4b, which are part of a vehicle power supply system 6. The first energy store 4a is in this case connected in a starter circuit element 6a in the vehicle power supply system 6 to a starter 8 for starting an engine, which is not illustrated in any more detail. The second energy store 4b is connected in a load circuit element 6b in the vehicle power supply system 6 to the loads 2 and to a generator 10. Further energy stores 4a to 4z with a further subdivision of the vehicle power supply system 6 into further circuit elements 6a to 6z may be provided, depending on the nature and configuration of the vehicle power supply system 6. The loads 2 may in this case be connected via respective switches, which are not illustrated in any more detail.

A coupling element 12 is provided for decoupling of the two circuit elements 6a and 6b from one another, or for

coupling one energy store 4b, for recharging as required, from the other energy store 4a. The coupling element 12 comprises, for example, a DC/DC voltage converter 12′ and/or a switch 12″, in particular a semiconductor switching element, such as a field-effect transistor.

The decoupling of the two circuit elements 6a and 6b allows the respective circuit element 6a or 6b to be controlled on the basis of its function - starter circuit element or load circuit element, respectively. In this case, the load circuit element 6b is used for feeding the loads 2, with these loads 2 being subdivided on the basis of their function into safety-relevant loads 2′ and loads 2 which are relevant for normal operation. The starter circuit element 6a is used together with the associated energy store 4a in particular to ensure the capability to start an associated technical system, for example an internal combustion engine.

The energy store 4b, referred to as the load battery, in the load circuit element 6b is, in particular, discharged continuously by the connected loads 2 and 2′ during operation of the arrangement 1. In order to recharge the energy store 4b, which is in the form of a load battery, it is connected to the generator 10, in order to supply it with energy, during operation of the arrangement 1.

In order to maintain the supply to the safety-relevant loads 2′, even in the event of failure of the energy store 4b, the arrangement 1 has an additional coupling element 14, which connects the loads 2′ which are classified as being safety-relevant to the starter circuit element 6a. The additional coupling element 14 is, for example, in the form of a semiconductor element, in particular a field-effect transistor.

A controller 16 is provided for open-loop and closed-loop control of the vehicle power supply system 6 and its circuit elements 6a and 6b, as well as the loads 2, 2′ connected thereto. In order to monitor and control the circuit elements 6a, 6b as well as the loads 2, 2′, the controller 16 has a data processing unit 18, for example a microprocessor. The coupling element 12, the additional coupling element 14 as well as the data processing unit 18 are integrated in the controller 16, depending on the nature and configuration of the arrangement 1.

Figure 2 shows the controller 16 in detail. The controller 16 is connected via a connection 20a to the energy store 4a for the starter circuit element 6a, and via a connection 20b and 20c to the energy store 4b and to the generator 10 for the load circuit element 6b. During normal operation of the arrangement 1, the loads 2 and loads 2′ which are classified as being safety-relevant are fed by means of the load circuit element 6b in the vehicle power supply system 6. In this case, the loads 2 and 2′ are connected to the load circuit element 6b for supply purposes via switched connections 20d or unswitched connections 20e. These may be protected or unprotected, depending on the nature and configuration of the outputs or connections 20a to 20e. Particularly safety-relevant connections 20a to 20e, for example the connection 20c, may in this case be protected by means of a protection device 21, for example a so-called pyrotechnic fuse.

In order to monitor the starter circuit element 6a and the load circuit element 6b, the controller 16 in each case has at least one measurement means 22 for detection of operating variables B which characterize the respective circuit element 6a or 6b. By way of example, the current I, the voltage U and/or the time t

is detected by means of the measurement means 22, as the operating variable B. The measurement means 22 for the respective circuit element 6a or 6b for this purpose has, for example, a voltmeter, an ammeter and/or a clock. The respective state of the associated energy store 4a or 4b is determined and established on the basis of the detected operating variables B(U, I, t) which characterize the respective circuit element 6a or 6b and are supplied to the data processing unit 18.

In order to provide a redundant connection for the loads 2′ which are classified as being safety-relevant, in addition to being linked to the load circuit element 6b, these are connected to the starter circuit element 6a by means of the additional coupling element 14. In this case, the controller 16 has one associated coupling element 14 for each safety-relevant load 2′. In order to further reduce the load on the starter circuit element 6a, and thus to ensure that the relevant energy store 4a has the capacity required for an emergency supply, the safety-relevant loads 2′ are coupled to the starter circuit element 6a entirely or largely without any quiescent current by means of the respective additional coupling element 14.

The arrangement allows the supply to the safety-relevant load 2′ to be monitored by the starter circuit element 6a during vehicle operation without any current flowing by means of the voltage of the energy store 4a (starter battery) which is applied to the safety-relevant load 2′ by the disconnected, additional coupling elements 14, irrespective of whether the load circuit element 6b suddenly fails or is still intact. Any faults are identified and indicated at the appropriate time. The described arrangement represents a three-stage supply concept with supply options which are largely independent of one another, and this forms the particular value of the arrangement. The first

stage is normal operation with the safety-relevant load 2′ being supplied by the load circuit element 6b and the availability of the supply to the safety-relevant load 2′ being monitored by the starter circuit element 6a via an associated coupling element 14. If the availability of the load circuit element 6b is constrained, the load circuit element 6b can be supported via the coupling element 12″ by the starter battery and the starter circuit element 6a, in order to ensure the overall supply. This represents stage 2. If a major defect occurs, with total failure of the load circuit element 6b, then the starter circuit element 6a and the load circuit element 6b are disconnected by disconnection of the coupling element 12″ or of a protection device in addition to the coupling element 12″, and the safety-relevant load 2′ is supplied only via the starter circuit element 6a from the starter battery. This represents stage 3. Together with the monitoring of the complete path for the supply and emergency supply, this represents a high-availability supply.

For this purpose, the respective coupling element 14 preferably has a field-effect transistor 24 and a diode 26, as well as a resistor 28 connected in parallel with them. A further field-effect transistor 30 may additionally be provided. The current Is can then be supplied via a connection 32, with the voltage Uc being supplied via a further connection 34, to the data processing unit 18 as the operating variable B for the respective safety-relevant load 2′.

The data processing unit 18 in the controller 16 can thus continuously monitor both the circuit elements 6a, 6b and the safety-relevant loads 2′. In this case, the data processing unit 18 uses the data recorded for the operating variables B(U, I, t) for the circuit elements 6a, 6b and for the safety-relevant loads 2′ to

determine the amount of charge drawn by each load 2', on the basis of which the appropriate load 2' which is classified as being safety-relevant is then connected and/or disconnected by means of control signals as a function of the capacity of the energy store 4a or 4b and/or the ranking of that particular load 2' which has been classified as being safety-relevant. In this case, depending on the state of the energy store 4b used to protect the basic supply, and which is also referred to as the load battery, for example in the event of its failure, the relevant safety-relevant load 2' is connected to the starter circuit element 6a, and thus to the energy store 4a, which is in the form of a starter battery, for the emergency supply.

In order to largely avoid the starter battery 4a being loaded by such an emergency supply during normal operation, the safety-relevant loads 2' are largely coupled without any quiescent current. In the situation where the capacity limit of the starter battery 4a is also undershot, individual loads 2' can be disconnected on the basis of their ranking by controlling appropriate coupling elements 14 for the respective safety-relevant loads 2'. Alternatively or additionally, an amount of energy, in particular the current that is required, can be allocated to the respective safety-relevant loads 2' by means of control signals. This prevents different loads 2' from interfering with one another.

Furthermore, a preferred supply to the safety-relevant loads 2' can be imposed by disconnection of coupling elements 14. This results in there being no quiescent current on the starter battery. Nevertheless, defects on the paths to the safety-relevant loads 2' can be fully monitored via the arrangement 20e, 29, 28 and 30, that is to say the connections 20e, a resistor 29, resistors 28 and a field-effect transistor 30, with

these defects being identified at the connections or outputs 34, which also allow voltage-controlled switching by means of the coupling element 14.

Figure 3 shows an arrangement 1 for a vehicle power supply system in a vehicle 36. The circuit elements 6a and 6b are arranged physically separately from one another in order to provide a multiple supply, which is sufficient even in critical situations, for safety-relevant loads 2'. By way of example, the starter circuit element 6a which is required for the starting capability and has the associated energy store 4a and the starter 8 is arranged at a position in the vehicle 36 that is particularly protected in the event of accidents, and is largely offset from the load circuit element 6b with the associated energy store 4b, or vice versa. This ensures that, even in the event of failure of one of the two energy stores 4a or 4b, it is possible to supply the loads 2' which have been classified as being safety-relevant by coupling the two circuit elements 6a and 6b by means of the power supply system coupling elements 12. The controller 16 is preferably likewise arranged at a point in the vehicle 36 which is particularly protected in the event of accidents.

Depending on the nature and configuration of the arrangement 1, the energy stores 4a and 4b may be of such a size that they have the amount of charge required for cold starting only when interconnected. A switching element 38, which couples the two energy stores 4a and 4b to one another, is provided for this purpose. Such sizes of the energy stores 4a and 4b with respect to them having a small individual capacity allows low costs and, in particular, a light weight.